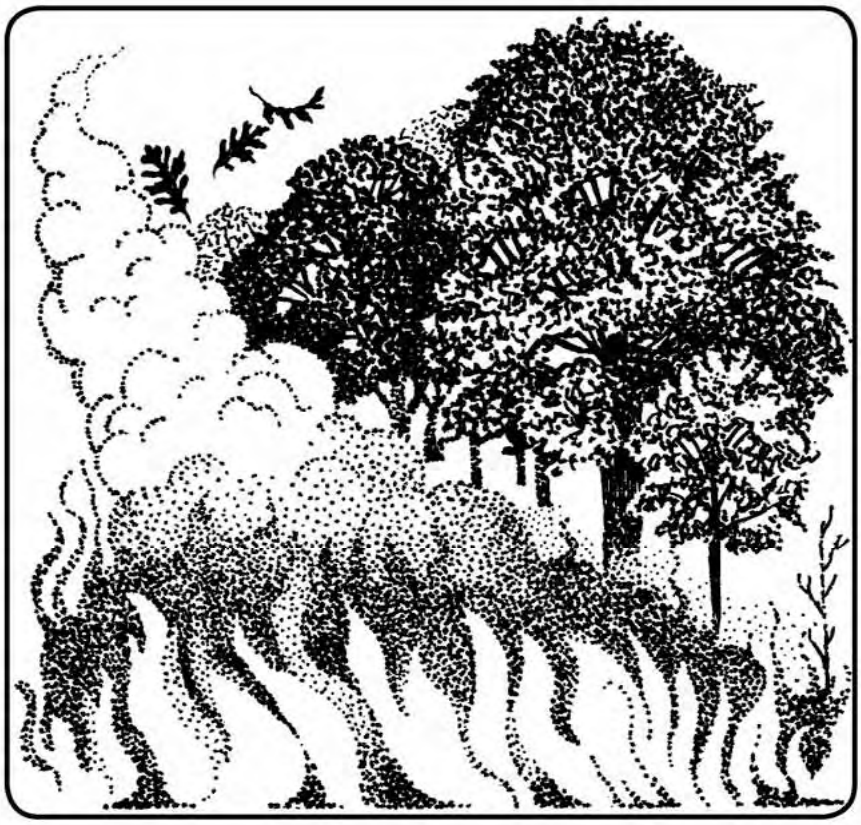
Forest Land

Missouri Department of Conservation

Management Guide

Use of Prescribed Fire



Forest Land Management Guide:

Use of Prescribed Fire

by

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Introduction

Prescribed fire is the safe use of fire under specific conditions to achieve land management objectives. Prescribed fire has been shown to be an effective land management tool in all of Missouri's habitats from the prairies of southwest Missouri to the agricultural lands of north Missouri to the swamps of southeast Missouri and throughout the Ozarks and river hills of the Missouri and Mississippi rivers.

Prescribed fire is not a cure all, as will be discussed later. Prescribed fire is also not a one-time, one-application tool. The effective use of prescribed fire requires a periodic reapplication to create and then maintain the desired habitat or stand condition. The reapplication rate and timing will vary with the need. Commitment to a long term program will continue the positive effects of the fire through periodic reburning.

Though an effective tool for managing Missouri landscapes, fire is and will probably continue to be a double-edged sword. Fires set indiscriminately or carelessly in wildland fuels will continue to threaten homes, towns and other wildland areas that should not be burned. These fires, termed wildfires, generally occur when conditions are too severe for prescribed burning and as a result are hard to confine and usually damage non-target areas. The Department spends a considerable amount of staff time and funds promoting wildfire prevention and control. It is the duty of staff using prescribed fire to use it responsibly and to educate the public on the need for caution and planning to achieve the benefits of this important land management tool without adding to the wildfire problem.

This document summarizes the state-of-the-art on prescribed fire in Missouri central hardwood forest types as of 2005. As our knowledge and skill for using prescribed fire has increased over the past 20 years, use and experimentation by management biologists and foresters will continue to expand our knowledge of applications where prescribed fire can be used effectively.

Historical Perspective of Wildland Fire in Missouri

Way Back When

Fire on the landscape has been a reality for thousands of years. The last glaciers left Missouri around 15,000 years ago. The land has been inhabited by people for about 12,000 years. These people, changing with the land and climate, have been documented as using fire for their betterment for at least the last 8,000 years. Archeological sites and soil boring samples in Kentucky indicate that resident aboriginal people were using fire to grow wild plants of the Chenopod (goosefoot) and Amaranth (pigweed) botanical families as a food source during these early times.

Later, written accounts from early European explorers and travelers commonly recorded native people using fire for land management. Aboriginal people commonly used fire to keep travel ways accessible and free of undergrowth. Fire was sometimes used to herd or drive game and to remove dead vegetation and attract game to lush new growth. Fire was used as a tactical weapon against rival tribes and as a defense strategy to reduce undergrowth that might conceal enemies near their camps. Native tribes of the Lake States even had special words for dark, dangerous (unburned) forests where enemies could hide and warriors could not draw their bows to defend themselves and their families.

Early settlers to Missouri saw landscapes that had, in many cases, been subjected to burning for centuries. Lands were typically open with herbaceous understory plants and grasses. Widely spaced trees allowed sunlight to penetrate to the ground for the herbaceous growth. This condition was the result of "Indian fires" or light surface fires every few years. Some of the settlers, especially those from Scotland and Ireland who settled in the Ozarks, brought a fire use history with them. Swidden agriculture, or the burning of stubble and vegetation prior to planting, was an established farming practice on the tillable reaches of their homelands.

However, with continued settlement wildland fires became more of a problem. Lack of concern or

the ability to control fires threatened the livelihoods of other settlers. Catastrophic fires in the Lake States and West during the early 1900s burned millions of acres, destroyed entire towns and killed thousands of people. Though these firestorms were fueled by the large amounts of logging slash from wide-scale logging and land clearing at the time of settlement and prolonged drought conditions, they illustrated just how terrible uncontrolled wildland fires could be.

The political mood of the nation was that since wildland fires could be bad, all fires were bad. Early foresters, trained in the European schools of thought, were unconditionally opposed to fires of any kind in the woods. Early suppression efforts were directed at putting out all fires as soon as possible. But that approach from a government entity didn't set well with the independent Scotch-Irish settlers with their basic distrust of government, so wildfires in the Ozarks continued as a major land treatment into the mid-1900s. By the mid-1900s, the efforts of the U.S. Forest Service (Smokey Bear) and the Missouri Department of Conservation were making good headway toward controlling the indiscriminate burning of the Ozarks on an annual basis.

Land Cover Without Fire

With the cessation of burning wildland fuels, the landscape changed. Without the disturbance of fires, in conjunction with the control of open range grazing by cattle and hogs, the wooded areas "brushed up" or became choked with shrubs and woody stems. A midstory of pole-sized trees formed that absorbed the light passing through the canopy. With no light reaching the forest floor and a buildup of leaf litter, herbaceous species were suppressed. Only those plants that could grow in moister, low-light conditions persisted. In this altered forest floor condition, shade tolerant species of trees became established. On richer, more mesic sites, sugar maple became the major component of the midstory. On drier sites in parts of the Ozarks, flowering dogwood and blackgum became major midstory species. The preponderance of these shade tolerant species in the midstory made it difficult or impossible for the shade intolerant oaks and hickories to regenerate and become established. When a stand was cut or subjected to natural mortality of the overstory trees, the shade tolerant species were poised to fill the opening in the canopy.

Heavily wooded landscapes were not the only ecosystems altered by the cessation of fire. Grassy areas such as glades and savannahs, and wetlands such as fens and swamps, were also impacted. Fens and swamps, wet by nature, had less fire disturbance to remove accumulated litter or to kill back the woody growth that invaded the shallow areas. The normally hot, dry glades became choked with litter which made the ground cooler and moister. This worked against the sun-loving native species and encouraged invasion by cool season vegetation and exotic species such as fescue. Woody species also became established in the ground layer, further shading the ground and continuing the demise of the glade and savannah communities.

Recent History

Prescribed fire has been used sporadically in Missouri throughout the history of the Conservation Department. It was used infrequently for site preparation and litter removal, but was not looked upon with favor.

In the 1970s, the wealth of information gleaned from several decades of studies in the prairies of the Great Plains became so overwhelming that prescribed burning was initiated on a small scale on public prairie lands. Concerns that Department use of prescribed fire would increase the wildfire problem from increased indiscriminate burning were not realized, and the values to the prairie communities were graphically illustrated.

Information gained from the prairie burning was used to advance the use of prescribed fire on all open lands in public ownership. Realizing the value of prescribed fire in agricultural operations, the Department and federal agencies started training and recommending the use of prescribed fire on open lands in private ownership. Strong concerns were raised about the potential to increase the wildfire problem. It was felt that once private landowners started using fire without the training and equipment available to public agency staff, wildfire incidents would increase. However, private landowners took a responsible approach to using prescribed fire, and there was no increase in the wildfire problem.

The belief that any fire in a wooded setting was bad permeated the ranks of professional foresters and

administrators. Department employees had spent their careers seeing the damage indiscriminate burning could do to the woods and the people that lived there. However, as the body of information increased on the value of prescribed burning in wooded settings, much of it from pioneering efforts of the U.S. Forest Service here in Missouri, it was clear that fire had a role in our hardwood forests. With stringent safeguards in place and with many concerned professionals observing, the use of fire in glade and savannah communities commenced. As with the other expansions in the fire management program, diligence by the burn crews and adequate planning prior to the burns provided for safe and effective prescribed fires that showed the value of this management tool, even in the wooded portions of Missouri.

Today we are using prescribed fire in all plant communities where it will help meet our management objectives. Prescribed fire is being promoted and used by private landowners across the state with our encouragement, training and support, even to the extent of loaning of specialized equipment and personnel to help with the burns. The wildfire problem has not grown as the result of increased prescribed burning, and land managers across the state have a valuable tool to help accomplish their land management objectives.

Why Prescribed Fire Works Today

Fires burned over Missouri for thousands of years before settlement by Europeans. Then fire was effectively stopped for 50 to 70 years. Now we are using it under prescribed conditions and it is having much the same effect as it had historically. Why?

Plant Physiology

Most of the plants native to our state have survived or thrived from the fire regimes of the past. The physiology of the plants developed with fire as part of their life cycle. The physiological attributes that provide native plants with the competitive advantage in a fire regime are many, but the most important characteristics are:

- **Sun loving.** Fire tolerant plants inhabit hotter, drier sites. They do not tolerate shade well. Many of the herbaceous plants do not initiate growth until the ground is well warmed. Oak seedlings use sunlight to develop root systems before extending their top growth, an adaptation to sunny, dry sites. Competing shade tolerant species, such as sugar maple, put on top growth first that shades and suppresses the shade intolerant oaks.

- **Lower growth points.** Fire tolerant herbaceous vegetation has sensitive growth points at or below ground level where they are not as prone to damage from fire. Fires that remove dead vegetation from the previous season's growth allow sunlight to penetrate to the growth point and initiate plant growth earlier in the spring, a management consideration.

- **Extensive root systems.** Both herbaceous plants and trees in fire environments develop extensive root systems that provide added drought tolerance. The root systems allow the plant to reach deeper soil moisture since the surface moisture is reduced by drying of the sun. The extensive root system also provides more soil holding capacity while the soil surface is exposed following a fire.

- **Thick bark and resprouting.** Woody species that are fire adapted are also sun loving (shade intolerant) as discussed earlier. However, they must survive fires during different stages of their life. Their main protection is from thicker bark that protects the cambium from the potentially lethal temperatures of a fire. In case of severe injury or death of the above ground portion of the woody plant, resprouting from the base or root collar will give the plant an increased chance of survival since the sprout can draw on water and nutrients from the entire root system of the old plant. Oaks are thick barked and prolific resprouters. Resprouting helps oaks make use of the sunlight and existing root system whether the above ground portion is killed or is harvested, a basic principle behind clearcutting stands of oak to encourage another oak forest to follow.

Wildlife Adaptations

As the plants of Missouri developed mechanisms for coping with the disturbance of fire, so did the animals. Most of the wildlife and all of Missouri's game animals except the ring-necked pheasant are native to the state and have existed with the habitat conditions created by fire's disturbance. In fact, some species have adapted so much to fire that fire exclusion and the resulting change in habitat has been detrimental to the species. Two habitat conditions and the

wildlife most affected when fire is excluded are:

- **Open vistas.** Examples are the prairie chicken and black-tailed jackrabbit, species that prefer open prairie vegetation, but require the open vistas and large areas of open, treeless land. The black-tailed jackrabbit is gone from Missouri, and prairie chicken populations are low and continue a steady decline. Collared lizards have shown these traits on a smaller scale. They expand their populations on glade complexes once the understory is opened up by fire so they can see adjacent glades.

- **Bare ground/ease of movement.** Many species, especially birds, require access to bare ground to find seeds and to dust for parasite control. When the bare ground is interspersed throughout stands of herbaceous or woodland vegetation, the seed and fruit are readily available to both the young and adults. Though birds such as bobwhite quail and turkey require residual vegetation for nest sites, they require availability of seeds from early successional vegetation as well as the mast from established vegetation. Insects drawn to early successional vegetation and mast contribute greatly to the diet of young broods. Small mammals and rabbits also utilize the available seeds. Thus the first two levels of the food chain are enhanced to favor the species that eat small herbivores.

Public Awareness

Prescribed fire is being used more today due to public acceptance that fire on the landscape can be good. Public awareness of the role of fire has been enhanced in two ways:

- **Multiple discipline support.** The scientific and historic role of fire continues to be studied and reported by multiple institutions. Universities, state and federal agencies, private advocacy groups and even agricultural and forest industries support and promote fire as a valid management tool. The value of fire disturbance in natural community, wildlife, grassland, woodland and forest management is being documented and presented to the public verbally, in writing and through visual media such as television.

- **Multiple benefits.** The value of fire disturbance in natural community and wildlife management is being realized. More importantly for many people are the direct economic benefits of fire. Increased cattle gains are available to ranchers and enhanced timber management can be a realization to forest managers. Add to this the political positions on limiting Western and Southern wildfires with fuel reduction fires, and the public sees more reasons to accept prescribed burning as a viable land management tool.

Prescribed Fire in Missouri's Wooded Settings

As with any other management tool, it is not sufficient go out and burn a tract of land because "fire is good." We prescribe cultural treatments for timber harvest, TSI and site preparation. We prescribe cropping, old field renovation and other management techniques for open land. All of this is predicated on an established need in order for the tract of land in question to achieve land management objectives. Following are some criteria for determining if fire is an applicable tool for certain landscape plant communities.

- **Glades.** Generally located on thin soils on south and west slopes, the harsh environment of glades generally precludes tree establishment. However, without any disturbance, woody growth will invade most glade areas. The growth will generally be redcedar, shrubby plants and trees of undesirable commercial species such as blackjack oak and black hickory. This woody growth competes directly with herbaceous vegetation for available water and nutrients. Since glade plants are sun loving, shading from woody growth further stresses the herbaceous layer. Stressed glade communities are more prone to contamination from invasive species such as tall fescue, sericea lespedeza and multiflora rose. Even in the absence of woody invasion, stagnation of the herbaceous stands can occur in the absence of fire. This stagnation is characterized by the lack of seed stalks/flowers, rank residual litter and invasion by exotic species.

- **Savannahs.** Located in the transition between open glades or prairies and the more moist woodlands, savannah habitat is generally described as scattered open-crowned trees with a herbaceous ground layer. Canopy coverage ranges from 10-30 percent. Shrub and midstory layers are sparse to absent. Though generally associated with prairies and glades, savannahs were historically common across Missouri on marginal soils, where water was limited or where fire was

frequent and fire intensity was great enough to inhibit woodland development. The pin oak/cordgrass savannahs found along the major drainages, such as the Grand River in north Missouri, are an example where fires inhibited the establishment of woodland or forest stands. Savannahs will benefit from a disturbance when any of the conditions that define a savannah start to change. That is, if the crown closure becomes too dense to allow for sunlight penetration, if a shrub or midstory starts to form or if the herbaceous layer becomes stagnant with a lack of flowering by the forbs or seed stalks by the grasses. If the overstory crown cover becomes excessive, mechanical removal, felling or deadening may be required to open the canopy. Frequent initial woody control treatments may be required to set back well-established stands of undesirable woody trees and shrubs.

- **Woodlands.** As you look at the continuum on a landscape, woodlands are more moist and shaded than savannahs but still open enough to allow a dense herbaceous layer. Woodlands have canopy coverages in the range of 30-90 percent and have sparser herbaceous layers that don't fill the ground cover until late summer. Woodlands typically have straight-limbed trees with somewhat spreading crowns. Management is needed when the canopy becomes so dense or a midstory develops that prevent sunlight from reaching the ground. Establishment of a midstory level and a reduction in the herbaceous cover indicates the need for active management. As with savannahs, removing woody growth larger than 4-5 inches dbh with fire will take a fire with an intensity that is likely to damage the residual stand and may be difficult to control. Mechanical harvest, felling or deadening should be used before the area is burned. As with savannahs, a short interval between initial and follow-up treatments may be required to allow the herbaceous layer to develop.

- **Forests.** Wooded land with adequate soils and moisture to grow and sustain highly productive wood fiber in terms of volume and quality is considered a forest for the purposes of this discussion. Forests are largely composed of (or could be composed of) trees with narrow crowns and clean trunks. The herbaceous layer is densest in early spring and becomes sparse into the summer due to the tree canopy. It may contain a shrub and midstory of small tree species or replacement trees for the overstory species. Prescribed fire is most beneficial to control the establishment of shade tolerant species such as sugar maple, blackgum and dogwood. It may also be needed to give oak seedlings a competitive advantage against the shade tolerant species that establish top growth quickly while oak seedlings are developing root systems rather that top growth. If oak seedlings do not get a competitive advantage over the less valuable shade tolerant species, the composition of the future forest will change toward shade tolerant species. A unique forest community in Missouri has shortleaf pine as an integral component. Pine management uses fire to control deciduous woody growth, including oaks and hickories. Though susceptible to fire as seedlings, pine quickly becomes fire resistant and within 3-5 years can withstand low intensity fires.

- **Exotic Species.** All of the habitat types discussed may be infested with exotic or invasive species such as fescue, sericea lespedeza, honeysuckle and black locust. These non-native species do not respond to prescribed fire the same as native plant communities. They may be stimulated by fire disturbance and spread into bare areas following the fire. Managers should consider exotic species control in coordination with plans to implement fire management. Herbicide or other cultural treatments of exotics both within and adjacent to the burn unit needs to be a part of the overall management program.

Fire Prescriptions

This section, with accompanying Table 1, will be the most useful reference of the guide, but knowledge of the background information used to develop these basic prescriptions is necessary to adequately understand and evaluate the effects of the management prescription. Always remember the timing and intensity of the fire will determine the fire effects on the plant community. Prescribed fire considerations:

- **Fuel load.** As fire frequency increases fuel load decreases, especially in woody fuels. The largest fuel load available for burning will be on the first fire. If high fire intensity is needed to meet your objectives, the first fire is your best chance for success. If a low intensity fire is needed to meet your objectives, be especially careful on the first burn and use firing techniques or weather conditions that will result in a low intensity/cooler fire, even with a high fuel load.

- **Weather.** Prescribed fire programs are predominately weather dependent. Weather conditions just prior to and during a prescribed fire have a tremendous impact on fire behavior. Low surface fuel moistures (drought, low humidities) and burning before an approaching cold front (erratic winds, low humidities) are the most common causes of major problems on the fireline. Consider weather conditions for the weeks before your burn (number of days since the last rainfall) as well as the burning day weather.

- **Slope and Aspect.** When burning a landscape-sized area, realize that fire behavior will vary greatly as the fire burns over different aspects. South and west slopes are drier and more susceptible to ignition and rapid buildups in intensity. Never forget that a fire on any aspect, wild or prescribed, will build in intensity and speed as it goes up a slope. In the Ozarks this can make a low intensity fire at the bottom of a slope a stand replacement fire by the time it reaches the upper slopes.

- **Time of Year.** There is value in burning at different times of the year. Certain plants are encouraged from summer and fall fires rather than during the dormant or spring burning season. In wooded settings, heat can be trapped under the canopy once trees leaf out, and that trapped heat can cause considerable damage to the residual stand. If you decide to do a fall burn on a wooded site that has an erosion potential, consider burning just before or during leaf drop. The residual leaves will provide some erosion control over winter until the herbaceous layer can respond to cover the ground.

  Summer burns can speed restoration efforts to control woody plant invasion, but require special considerations for both the burn area and the crew conducting the burn. To be successful, woody canopy coverage, if present, should be less than 50 percent; otherwise fuel moisture will generally be too high to burn. Two years of residual material is needed to carry a fire. Firelines for summer fires can range from disked lines in the open to narrow lines under closed canopy trees. If using mowed lines, plenty of water is necessary to protect the integrity of the line. Firelines and ignition plans should be developed to minimize crew and equipment exposure to the heat of the fire. Crew safety from overheating should be the burn boss's highest priority. Summer burns also require more public education since these fires will often coincide with media coverage of western wildfires.

Prescription Parameters

Use these general guidelines to develop initial burn prescriptions, but refine them over time to best meet your management objectives.

Glades. Burn every 2-3 years, or as fuel becomes available, until the desired condition is achieved. Burn every 3-5 years to maintain openness and vigorous herbaceous growth.

- Timing – Spring burn during restoration; rotate to a fall burn every third or fourth burn once in a maintenance mode. The earlier the burn in the spring (dormant season) the more benefit to the forb species; the later in the spring the more benefit to the grass species. If woody growth has been felled prior to burn, let it cure for six months to one year to allow for drying and consumption during the burn. Note: If fescue invasion is a problem, early spring burns will enhance fescue growth.

- Fire behavior – It will be a moderate intensity fire except in downed cedars where high intensity will result. Flame lengths will be 3-5 feet except in cedar or down timber. Use a head fire as much as possible during initial burns if ground cover is sparse and fuels are not continuous.

General Parameters:

- Dates – March 1- April 15
- Wind – 3-10 mph midflame (eye level)
- Temperature – 40-75° F
- Relative Humidity – 25-45%
- 1-hr fuel – 6-9%
- 10-hr fuel – 7-10%

Savannahs. Burn every 2-3 years as fuel is available until the desired conditions are achieved. Burn every 4-6 years to maintain vigor in the herbaceous layer and to control woody invasion. Over the life of the stand, there will need to be a 10-15 year fire-free interval in at least part of the stand where selected sprouts can develop into fire-resistant pole-sized trees. Use caution to reduce fire intensities when reinstating fire after the fire-free interval.

- Timing – Spring burn during restoration and rotate with a fall burn every third or fourth burn

once in a maintenance mode. If overstory or midstory cutting is part of the prescription, let fallen wood dry six months to one year and do not leave any tops or fuel jackpots close to the residual trees.

- Fire Behavior – During restoration, burn first to remove woody vegetation and secondly to establish herbaceous layer. Temper fire intensity/firing pattern with amount of woody vegetation to be killed and damage to the residual stand. The larger the desired residual trees, the greater the fire intensity they can withstand. Flame lengths of 1-2 feet will maintain herbaceous layer and top kill stems with basal diameters of less than 1 inch. Flame lengths of 3-5 feet will top kill small woody stems up to 4 or 5 inches dbh depending on species and conditions, but are likely to damage residual stands. Flame lengths in excess of 5 feet may kill large overstory trees and are difficult to contain. Upslope fires and fires moving with the wind in herbaceous fuels will product the most intense flaming fronts.

General Parameters:

- Dates – Feb. 1 to April 1 (before leaf out)
- Wind – 3-10 mph midflame (eye level)
- Temperature – 40-75° F
- Relative Humidity – 25-45%
- 1-hr. fuel – 6-9%
- 10-hr. fuel – 7-10%
- 100-hr. fuel – 13-17% (low=consumption; high=protection)
- 1,000-hr fuel – >18%

Woodlands. Burn with low intensity fires every 2-3 years during restoration phase. Burn every 4-6 years to maintain herbaceous plant vigor and to control woody invasion. Since woodlands are moister and less fire prone than savannahs, the potential for woody encroachment is increased.

- Timing – Dormant season and early spring burns will be most effective due to the increased shading from the leaves in the canopy and the potential for damage to trees from heat trapped within the canopy during growing season burns. Once the woodland is in the desired condition, a low intensity fall burn every third or fourth burn in the cycle will enhance the diversity of the herbaceous layer.

- Fire Behavior – Most fires in woodlands should be low intensity to consume herbaceous litter and to control small woody stems (shrubs, tree seedlings). Flame lengths of 2-4 feet will accomplish this objective without doing major damage to larger woody stems. However, with these lower intensity fires, it is more likely that other cultural treatments will be necessary to control woody stems greater than 1 inch dbh.

General Parameters:

- Dates – Feb. 1 to April 1 (before leaf out)
- Wind – 3-8 mph midflame (eye level)
- Temperature – 40-65° F
- Relative Humidity – 30-50%
- 1-hr fuel – 6-9%
- 10-hr fuel – 7-10%
- 100-hr fuel – 13-17%
- 1,000-hr fuel – >18%

Forests. Burn forests in line with management objectives. If forest products are not an objective, periodic burning will encourage sedges and moist site forbs that provide early forage for herbivores such as deer and turkey. Frequent, low intensity fires (the Indian fires of old) will keep the understory more open and speed the recycling of leaf litter into ash and its component nutrients. Burning every 3-5 years should maintain some herbaceous diversity in the understory. If forest products are a major objective, and perpetuation of oaks is desirable, three burns in the 10 years prior to harvest may increase the amount of oak regeneration in the understory and control the shade tolerant species. Other options are to culturally remove competing shade tolerant species or those too large for fire to kill and then do a shelterwood harvest with fires every two or three years until sufficient advanced oak regeneration is present to remove the shelterwood trees. Please note: The forest will dictate the need for fire as a tool that promotes oak regeneration. Especially on drier sites, oak may regenerate in acceptable amounts without fire.

- Timing – Dormant season and early spring burns prior to leaf out are the most feasible. Once the canopy leafs out, fuel moisture will rise and burning will be difficult. Burning during short term drought conditions throughout the growing season are damaging to the residual stand due to the intense heat generated and the amount of that heat that will be trapped under the canopy.

- Fire Behavior – Low intensity fires are desirable. Flame lengths in the 1-3 foot range should

achieve management objectives for the herbaceous layer. If burning under a shelterwood, flame lengths of 3-5 feet will help control the larger shade tolerant species (dbh <5 inches).

General Parameters:

- Dates – Feb. 1 to April 1 (prior to oak leaf out)
- Wind – 0-5 mph midflame (eye level)
- Temperature – 40-65° F
- Relative Humidity – 30-50%
- 1-hr fuel – 8-10%
- 10-hr fuel – 9-10%
- 100-hr fuel – >15%
- 1,000-hr fuel – >18 %

Summer Burns. When burning in the summer, the benefits will be an increase in the control of woody understory or old field invaders and the hazards are heat stress to crew and equipment. Though flame lengths are generally low, heat produced by the fire, combined with the higher ambient temperatures, produce higher fireline intensities and therefore increased fire effects on the vegetation.

- Timing – July 15 to September 15 is desirable. Burns delayed until July 15 allows increased fledging of ground nesting birds such as quail.

- Fire Behavior – High ambient temperatures combine with the flames to produce high fire intensities near the flaming front, even with low flame lengths.

General Parameters:

- Dates – July 15 to September 15
- Wind – 3-8 mph midflame (eye level)
- Temperature – 60-100° F
- Relative Humidity – 30-60%
- 1-hr fuel – 6-9%
- 10-hr fuel – 7-10%
- 100-hr fuel – >13%
- 1,000 hr fuel – >18%

Landscapes. When burning landscape-sized units, evaluate the needs of all the habitat types and target those with the highest priority for success. Also develop fire behavior prescriptions that account for variations in aspect and slope across the landscape unit. Realize that fire changes its intensity and behavior as it progresses over every foot of ground due to small changes in fuel, microclimate and topography. Across a landscape, target the highest priority objectives and accept the fire effects on the lower priority habitats that may not be burned under their most desirable prescription. Remember that as the burn day progresses into late afternoon, relative humidities will generally drop, resulting in the hottest fire conditions.

Future Challenges for Fire Managers in Missouri

As prescribed fire has developed into an accepted land management tool in Missouri, additional challenges face the expanded and future uses of fire.

1. **Fire impacts on commercial timber in Missouri.** We do not have quantifiable information on fire impacts to commercial timber under prescribed conditions. We need to be able to model potential injury, scarring and mortality from prescribed fires under certain fuel and weather conditions to adequately evaluate the benefit trade-offs when using fire in commercial timber stands.

2. **Increasing populations in the wildland/urban interface.** Missouri is rapidly becoming populated throughout the state with either seasonal or permanent dwellings. These structures and their occupants create added risks and require added planning by land managers using prescribed fire. Public acceptance of prescribed fire, even when it is across the fence, will require education, one-on-one contact and modification of burn plans to ease the anxiety of homeowners living close to our prescribed burns.

3. **Increasing environmental regulations.** As our society continues to age and become more urbanized, their tolerance of prescribed fire by-products, such as smoke, lessens. Their attitudes are reflected in environmental regulations that may limit or exclude the use of prescribed fire in parts of the state. The best offense to ease public concerns and avert future legislation is quantifying emissions, developing guidelines that address smoke management in more detail and educating a public that has lost touch with wildlands and the benefits achieved through the continued use of prescribed fire.

Table 1. General Prescribed Fire Parameters

Land Cover	Timing	Fire Behavior	Dates	Fire Weather			Fuel Moisture (%)			
				Wind (midflame)	Temp (°F)	RH (%)	1-hr.	10-hr.	100-hr.	1,000-hr.
Glades	Restore: every 2-3 yr. (dormant) Maintain: every 3-5 yr. (fall or spring)	Moderate intensity; Flame 3-5 ft.; Ring or head fire	March 1-April 15	3-10 mph	40-75°	25-45	6-9	7-10		
Savannahs	Restore: every 2-3 yrs. (dormant) Maintain: every 4-6 yrs. (fall or spring)	Flame 1-2 ft. for herbaceous; 3-5 ft. for woody	Feb. 1-April 1	3-10 mph	40-75°	25-45	6-9	7-10	13-17	>18
Woodlands	Restore: every 2-3 yrs. (dormant) Maintain: every 4-6 yrs. (fall or spring)	Flame 2-4 ft.	Feb. 1-April 1	3-8 mph	40-65°	30-50	6-9	7-10	13-17	>18
Forest	Restore: every 3-5 yrs. (dormant) Maintain: every 5-10 yrs. (dormant)	Flame 1-3 ft.	Feb. 1-April 1	0-5 mph	40-65°	30-50	8-10	9-10	>15	>18
Forest Products	Dormant Season - 3 fires 10 yrs. prior to harvest **or** shelterwood and every 2-3 years for advanced regen	Flame 1-3 ft.	Feb. 1-April 1	0-5 mph	40-65°	30-50	8-10	9-10	>15	>18
Summer Burns	At least 2 yrs. of residual fuel on the ground	Canopy <50%	July 15-Sept. 15	3-8 mph	60-100°	30-60	6-9	7-10	>13	>18
Landscapes	Select highest priority management objectives	Consider topography, fuel variations								